Table 4.10 - Results of Duplicate Surface Water Sample Analysis. Units are Bq/l. See Appendix B for the sampling locations.

Location	[RN][a]	2×TPU[b]	MDC[c]	RER[d]	[RN]	2×TPU	MDC	RER
	^{241}Am				^{238}Pu			
IDN	3.05×10^{-4}	7.47×10^{-4}	1.42×10^{-4}	0.050	0.00×10^{0}	0.00×10^{0}	7.59×10^{-4}	0.500
IDN Dup.	2.63×10^{-4}	3.74×10^{-4}	3.57×10^{-4}		1.96×10^{-4}	3.92×10^{-4}	5.29×10^{-4}	
TUT	1.22×10^{-4}	5.48×10^{-4}	1.14×10^{-3}	0.495	2.13×10^{-4}	3.03×10^{-4}	2.88×10^{-4}	0.407
TUT Dup.	4.85×10^{-4}	4.88×10^{-4}	3.28×10^{-4}		5.62×10^{-4}	8.03×10^{-4}	7.62×10^{-4}	
	$^{239+240}$Pu				^{234}U			
IDN	4.11×10^{-4}	4.18×10^{-4}	2.79×10^{-4}	0.983	1.21×10^{-2}	3.00×10^{-3}	7.99×10^{-4}	0.355
IDN Dup.	0.00×10^{0}	0.00×10^{0}	5.29×10^{-4}		1.37×10^{-2}	3.36×10^{-3}	3.16×10^{-4}	
TUT	1.06×10^{-4}	2.13×10^{-4}	2.88×10^{-4}	0.288	9.66×10^{-3}	2.49×10^{-3}	2.76×10^{-4}	0.818
TUT Dup.	2.80×10^{-4}	5.66×10^{-4}	7.62×10^{-4}		1.45×10^{-2}	5.37×10^{-3}	8.55×10^{-4}	
	^{235}U				^{238}U			
IDN	9.36×10^{-4}	8.14×10^{-4}	9.84×10^{-4}	0.066	1.22×10^{-2}	3.00×10^{-3}	2.92×10^{-4}	0.693
IDN Dup.	1.01×10^{-3}	7.81×10^{-4}	3.89×10^{-4}		9.40×10^{-3}	2.61×10^{-3}	8.55×10^{-4}	
TUT	5.03×10^{-4}	5.07×10^{-4}	3.40×10^{-4}	0.122	7.81×10^{-3}	2.15×10^{-3}	2.75×10^{-4}	0.704
TUT Dup.	3.89×10^{-4}	7.84×10^{-4}	1.05×10^{-3}		5.33×10^{-3}	2.86×10^{-3}	8.51×10^{-4}	

[a] [RN] = Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative Error Ratio

4.6 Soil Samples

4.6.1 Sampling

Soil samples were collected from near the low-volume air samplers at six different locations around the WIPP site: MLR, SEC, SMR, WEE, WFF, and WSS (Figure 4.6). Samples were collected from each location in three incremental profiles: surface soil (SS, 0-2 cm [0-0.8 in.]), intermediate soil (SI, 2-5 cm [0.8-2 in.]), and deep soil (SD, 5-10 cm [2-4 in.]). Measurements of radionuclides in depth profiles provide information about their vertical movements in the soil systems.

4.6.2 Sample Preparation

Soil samples were dried at 110°C (230°F) for several hours and homogenized by grinding to small particle sizes. One gram (0.04 oz) of soil was dissolved by heating it with a mixture of nitric, hydrochloric, and hydrofluoric acids. Finally, it was heated with nitric and boric acids, and the residue was dissolved in hydrochloric acid for the determination of individual radionuclides.

4.6.3 Determination of Individual Radionuclides

Gamma-emitting radionuclides (^{40}K, ^{60}Co, and ^{137}Cs) were determined by counting an aliquot of well-homogenized ground soil samples by gamma-spectrometry. Strontium-90 was analyzed from an aliquot of the sample solution by separating it from other stable and radioactive elements using radiochemical techniques and beta counting. Another aliquot of the sample solution was used for the sequential determinations of alpha-emitting radionuclides, such as ^{234}U, ^{235}U, and ^{238}U; ^{238}Pu and $^{239+240}Pu$; and ^{241}Am. These radionuclides were separated from the bulk of the inorganic materials present in the soil samples and from one another by radiochemical separations including co-precipitation and ion-exchange chromatography. Finally, the samples were micro-precipitated, filtered onto micro-filters, and counted on the alpha spectrometer.

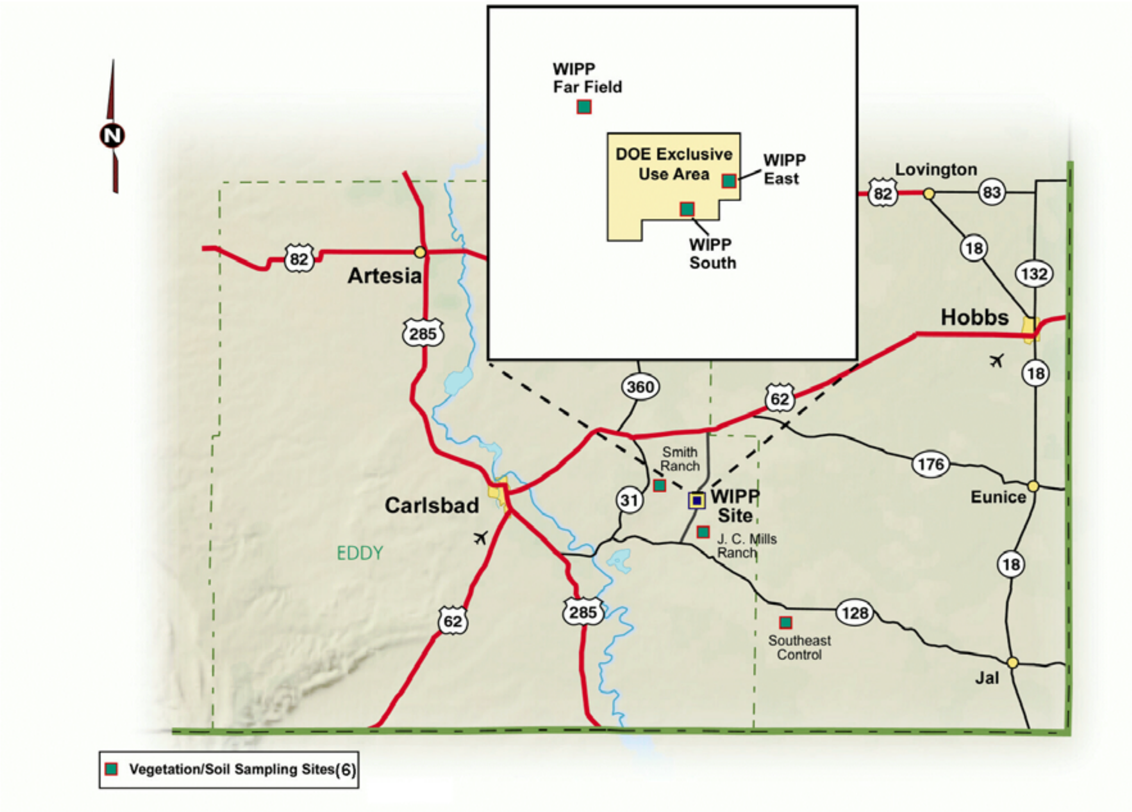

Figure 4.6 - Soil and Vegetation Sampling Areas in 2001

4.6.4 Results and Discussions

Uranium-234 and ^{238}U were detected in every soil sample in 2001 and ^{235}U was detected in all but one. Concentrations of ^{234}U in surface soils (0-2 cm) ranged from a minimum of $5.66\times10^{-3} \pm 1.35\times10^{-3}$ Bq/g ($1.53\times10^{-1} \pm 3.65\times10^{-2}$ pCi/g) at WEE to a maximum of $1.25\times10^{-2} \pm 2.48\times10^{-3}$ Bq/g ($3.38\times10^{-1} \pm 6.70\times10^{-2}$ pCi/g) at SEC (Table 4.11). Concentrations of ^{235}U in the same samples ranged from $2.83\times10^{-4} \pm 2.72\times10^{-4}$ Bq/g ($7.65\times10^{-3} \pm 7.35\times10^{-3}$ pCi/g) at WFF to $2.32\times10^{-3} \pm 2.48\times10^{-4}$ Bq/g ($6.27\times10^{-2} \pm 6.70\times10^{-3}$ pCi/g) at WEE. The concentration of ^{238}U in surface soils ranged from $6.85\times10^{-3} \pm 1.57\times10^{-3}$ Bq/g ($1.85\times10^{-1} \pm 4.24\times10^{-2}$ pCi/g) at WEE to $1.28\times10^{-2} \pm 2.63\times10^{-3}$ Bq/g ($3.46\times10^{-1} \pm 7.11\times10^{-1}$ pCi/g) at WFF.

The results for uranium in intermediate depth (2-5 cm) soil samples are also given in Table 4.11. The concentration of ^{234}U ranged from $6.73\times10^{-3} \pm 1.38\times10^{-3}$ Bq/g ($1.82\times10^{-1} \pm 3.73\times10^{-2}$ pCi/g) at WEE to $2.03\times10^{-2} \pm 3.92\times10^{-3}$ Bq/g (5.49×10^{-1} ±

1.06×10^{-1} pCi/g) at SEC. Uranium-235 in these soils was lowest at WEE (3.92×10^{-4} ± 2.43×10^{-4} Bq/g [1.06×10^{-2} ± 6.57×10^{-3} pCi/g]) and highest at SEC (1.11×10^{-3} ± 4.92×10^{-4} Bq/g [3.00×10^{-2} ± 1.16×10^{-2} pCi/g]). The concentration of ^{238}U ranged from 7.33×10^{-3} ± 1.48×10^{-3} Bq/g (1.98×10^{-1} ± 4.00×10^{-2} pCi/g) at WEE to 2.27×10^{-2} ± 4.33×10^{-3} Bq/g (6.14×10^{-1} ± 1.17×10^{-1} pCi/g) at SEC.

Table 4.11 - Uranium Concentrations (Bq/g) in Soil Near the WIPP Site. See Appendix B for the sampling locations.

Location	Depth (cm)	[RN][a]	2 × TPU[b]	MDC[c]	[RN]	2 × TPU	MDC	[RN]	2 × TPU	MDC
		^{234}U			^{235}U			^{238}U		
MLR	0-2	1.20×10^{-2}	2.22×10^{-3}	2.19×10^{-4}	4.77×10^{-4}	2.75×10^{-4}	9.95×10^{-5}	1.13×10^{-2}	2.10×10^{-3}	8.03×10^{-5}
MLR	2-5	1.41×10^{-2}	2.45×10^{-3}	7.22×10^{-5}	4.92×10^{-4}	2.66×10^{-4}	8.92×10^{-2}	1.32×10^{-2}	2.32×10^{-3}	2.47×10^{-4}
MLR	5-10	1.18×10^{-2}	2.13×10^{-3}	6.99×10^{-5}	6.36×10^{-4}	3.00×10^{-4}	8.62×10^{-5}	1.17×10^{-2}	2.11×10^{-3}	6.96×10^{-5}
SEC	0-2	1.25×10^{-2}	2.48×10^{-3}	2.47×10^{-4}	1.03×10^{-3}	4.48×10^{-4}	1.12×10^{-4}	1.28×10^{-2}	2.52×10^{-3}	9.03×10^{-5}
SEC	2-5	2.03×10^{-2}	3.92×10^{-3}	2.77×10^{-4}	1.11×10^{-3}	4.92×10^{-4}	1.25×10^{-4}	2.27×10^{-2}	4.33×10^{-3}	1.01×10^{-4}
SEC	5-10	1.90×10^{-2}	3.50×10^{-3}	8.77×10^{-5}	8.40×10^{-4}	4.07×10^{-4}	2.95×10^{-4}	1.61×10^{-2}	3.02×10^{-3}	2.38×10^{-4}
SMR	0-2	1.04×10^{-2}	1.92×10^{-3}	7.18×10^{-5}	4.59×10^{-4}	2.55×10^{-4}	8.84×10^{-5}	1.09×10^{-2}	2.00×10^{-3}	7.14×10^{-5}
SMR	2-5	1.11×10^{-2}	2.02×10^{-3}	7.22×10^{-5}	7.22×10^{-4}	3.27×10^{-3}	8.88×10^{-5}	1.14×10^{-2}	2.06×10^{-3}	7.18×10^{-5}
SMR	5-10	2.09×10^{-2}	3.74×10^{-3}	8.51×10^{-5}	8.92×10^{-4}	4.00×10^{-4}	1.05×10^{-4}	2.09×10^{-2}	3.74×10^{-3}	8.47×10^{-5}
WEE	0-2	5.66×10^{-3}	1.35×10^{-3}	1.02×10^{-4}	2.32×10^{-5}	2.48×10^{-4}	3.41×10^{-4}	6.85×10^{-3}	1.57×10^{-3}	1.01×10^{-4}
WEE	2-5	6.73×10^{-3}	1.38×10^{-3}	7.81×10^{-5}	3.92×10^{-4}	2.43×10^{-4}	9.62×10^{-5}	7.33×10^{-3}	1.48×10^{-3}	7.77×10^{-5}
WEE	5-10	1.84×10^{-2}	3.68×10^{-3}	2.83×10^{-4}	4.74×10^{-4}	3.11×10^{-4}	1.28×10^{-4}	2.00×10^{-2}	3.96×10^{-3}	1.04×10^{-4}
WFF	0-2	1.17×10^{-2}	2.45×10^{-3}	1.04×10^{-4}	2.83×10^{-4}	2.72×10^{-4}	3.48×10^{-4}	1.28×10^{-2}	2.63×10^{-3}	2.80×10^{-4}
WFF	2-5	1.22×10^{-2}	2.62×10^{-3}	3.56×10^{-4}	6.62×10^{-4}	3.74×10^{-4}	1.28×10^{-4}	1.23×10^{-2}	2.62×10^{-3}	2.81×10^{-4}
WFF	5-10	1.00×10^{-2}	2.18×10^{-3}	1.08×10^{-4}	2.96×10^{-4}	2.47×10^{-4}	1.34×10^{-4}	9.36×10^{-3}	2.05×10^{-3}	1.08×10^{-4}
WSS	0-2	1.24×10^{-2}	2.37×10^{-3}	2.92×10^{-4}	4.26×10^{-4}	2.66×10^{-4}	1.05×10^{-4}	1.25×10^{-2}	2.39×10^{-3}	2.30×10^{-4}
WSS	2-5	9.58×10^{-3}	1.97×10^{-3}	9.25×10^{-5}	7.99×10^{-4}	3.92×10^{-4}	1.14×10^{-4}	9.18×10^{-3}	1.53×10^{-3}	9.18×10^{-5}
WSS	5-10	8.73×10^{-3}	1.86×10^{-3}	9.77×10^{-5}	1.78×10^{-4}	1.81×10^{-4}	1.21×10^{-4}	8.51×10^{-3}	1.82×10^{-3}	9.73×10^{-5}

[a] [RN] = Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Concentrations of ^{234}U, ^{235}U, and ^{238}U were also measured in deep soils (5-10 cm) (Table 4.11). Concentrations of ^{234}U varied from 8.73×10^{-3} ± 1.86×10^{-3} Bq/g (2.36×10^{-1} ± 5.03×10^{-2} pCi/g) at WSS to 2.09×10^{-2} ± 3.74×10^{-3} Bq/g (5.65×10^{-1} ± 1.01×10^{-1} pCi/g) at SMR. The lowest concentration of ^{235}U in deep soils was found at WSS (1.78×10^{-4} ± 1.81×10^{-4} Bq/g [4.81×10^{-3} ± 4.89×10^{-3} pCi/g]) and the highest concentration was found at SMR (8.92×10^{-4} ± 4.00×10^{-4} Bq/g [2.41×10^{-2} ± 1.08×10^{-2} pCi/g]). Uranium-238 lowest concentration was 8.51×10^{-3} ± 1.82×10^{-3} Bq/g (2.30×10^{-1} ± 4.92×10^{-2} pCi/g) at WSS and the highest was found 2.09×10^{-2} ± 3.74×10^{-3} Bq/g (5.65×10^{-1} ± 1.01×10^{-1} pCi/g) at SMR.

No uranium isotope varied significantly with year 2001 (ANOVA, ^{234}U $p = 0.105$, ^{238}U $p = 0.722$). All maximum measured concentrations fell within the range of natural concentrations of uranium found in soils throughout the world (Pais and Jones 1997). All these results suggest a pattern of natural variability consistent with the existence of natural uranium, without amendment from artificial sources.

Plutonium-238, $^{239+240}$Pu, and ^{241}Am were also analyzed in these soil samples (Table 4.12). Plutonium-238 was not detected in any samples. The measured concentration of $^{239+240}$Pu was greater than the MDC at location MLR at all three depths. The ^{241}Am concentration was greater than the MDC at MLR, 0-2 cm and 2-5 cm, SEC, 5-10cm, and WEE, 5-10cm. Historically, soil samples collected in the same locations have shown positive results on numerous occasions. Since 1997, soil samples collected by the Environmental Monitoring group at WEE, SEC, and MLR have shown levels of ^{241}Am and $^{239/240}$Pu slightly above background. During this time period, three different analytical laboratories were used; all had similar results. The source of activity in WIPP samples could be due to natural transport of contaminated soil from the Gnome Site via wind. The Gnome Site lies about 9km southwest of the WIPP boundary and was contaminated with fission products in 1961 when an underground test of a 3-kiloton ^{239}Pu device vented to the surface. Because there are elevated levels of radionuclides in the soil near the Gnome Site, there is potential for contamination of WIPP environmental samples. The measurable levels of radionuclides remains relatively high around the Gnome Site despite remediation efforts.

Table 4.12 - Americium and Plutonium Concentrations (Bq/g) in Soil Near the WIPP Site. See Appendix B for the sampling locations.

Location	Depth (cm)	[RN][a]	2 × TPU[b]	MDC[c]	[RN]	2 × TPU	MDC	[RN]	2 × TPU	MDC
		^{241}Am			^{238}Pu			$^{239+240}$Pu		
MLR	0-2	1.79×10^{-4}	1.49×10^{-4}	8.07×10^{-5}	-3.43×10^{-5}	6.88×10^{-5}	2.52×10^{-4}	3.42×10^{-4}	2.23×10^{-4}	9.29×10^{-5}
MLR	2-5	4.18×10^{-4}	2.29×10^{-4}	8.10×10^{-5}	0.00×10^{0}	0.00×10^{0}	1.28×10^{-4}	6.59×10^{-4}	3.70×10^{-4}	1.28×10^{-4}
MLR	5-10	2.41×10^{-4}	2.31×10^{-4}	3.19×10^{-4}	-4.88×10^{-5}	9.84×10^{-5}	3.60×10^{-4}	5.85×10^{-4}	3.55×10^{-4}	1.32×10^{-4}
SEC	0-2	3.23×10^{-5}	1.45×10^{-4}	3.00×10^{-4}	4.44×10^{-5}	8.92×10^{-5}	1.20×10^{-4}	1.77×10^{-4}	1.80×10^{-4}	1.20×10^{-4}
SEC	2-5	8.95×10^{-5}	1.34×10^{-4}	2.20×10^{-4}	1.70×10^{-4}	2.10×10^{-4}	3.13×10^{-4}	1.70×10^{-4}	1.72×10^{-4}	1.15×10^{-4}
SEC	5-10	1.37×10^{-4}	1.16×10^{-4}	8.99×10^{-4}	6.29×10^{-5}	1.26×10^{-4}	2.31×10^{-4}	6.25×10^{-5}	1.26×10^{-4}	2.31×10^{-4}
SMR	0-2	0.00×10^{0}	0.00×10^{0}	2.21×10^{-4}	-4.07×10^{-5}	8.14×10^{-5}	2.99×10^{-4}	0.00×10^{0}	0.00×10^{0}	2.99×10^{-4}
SMR	2-5	8.03×10^{-5}	1.15×10^{-4}	1.09×10^{-4}	0.00×10^{0}	0.00×10^{0}	1.30×10^{-4}	0.00×10^{0}	0.00×10^{0}	3.52×10^{-4}
SMR	5-10	2.98×10^{-5}	1.34×10^{-4}	2.78×10^{-4}	-6.62×10^{-5}	9.44×10^{-5}	3.07×10^{-4}	3.30×10^{-5}	1.15×10^{-4}	2.43×10^{-4}
WEE	0-2	6.33×10^{-5}	9.03×10^{-5}	8.58×10^{-5}	0.00×10^{0}	0.00×10^{0}	9.81×10^{-5}	3.61×10^{-5}	7.25×10^{-5}	9.81×10^{-5}
WEE	2-5	0.00×10^{0}	0.00×10^{0}	3.47×10^{-4}	3.96×10^{-5}	7.92×10^{-5}	1.07×10^{-4}	1.58×10^{-4}	1.60×10^{-4}	1.07×10^{-4}
WEE	5-10	1.32×10^{-4}	1.54×10^{-4}	1.19×10^{-4}	0.00×10^{0}	0.00×10^{0}	2.25×10^{-4}	9.18×10^{-5}	1.07×10^{-4}	8.29×10^{-5}
WFF	0-2	1.68×10^{-4}	1.71×10^{-4}	1.14×10^{-4}	4.14×10^{-5}	8.29×10^{-5}	1.12×10^{-4}	1.65×10^{-4}	1.67×10^{-4}	1.12×10^{-4}
WFF	2-5	1.96×10^{-4}	2.09×10^{-4}	3.03×10^{-4}	8.51×10^{-5}	2.95×10^{-4}	6.25×10^{-4}	8.51×10^{-5}	1.71×10^{-4}	2.30×10^{-4}
WFF	5-10	5.62×10^{-5}	1.95×10^{-4}	4.14×10^{-4}	1.18×10^{-4}	1.77×10^{-4}	2.89×10^{-4}	7.84×10^{-5}	1.12×10^{-4}	1.06×10^{-4}
WSS	0-2	-3.25×10^{-5}	1.45×10^{-4}	3.50×10^{-4}	0.00×10^{0}	0.00×10^{0}	9.21×10^{-5}	1.36×10^{-4}	1.38×10^{-4}	9.21×10^{-5}
WSS	2-5	7.29×10^{-5}	1.04×10^{-4}	9.48×10^{-5}	-3.53×10^{-5}	1.22×10^{-4}	3.27×10^{-4}	7.03×10^{-5}	1.00×10^{-4}	9.55×10^{-5}
WSS	5-10	1.21×10^{-4}	1.73×10^{-4}	2.82×10^{-4}	9.62×10^{-5}	1.37×10^{-4}	1.30×10^{-4}	4.81×10^{-5}	1.67×10^{-4}	3.54×10^{-4}

[a] [RN] = Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Potassium-40, as expected, was detected in every sample (Table 4.13). This naturally-occurring gamma-emitting radionuclide is ubiquitous in soils. Concentrations in surface soils ranged from $2.24\times10^{-1} \pm 3.05\times10^{-2}$ Bq/g ($6.05\times10^{0} \pm 8.24\times10^{-1}$ pCi/g) at SEC to $4.74\times10^{-1} \pm 6.18\times10^{-2}$ Bq/g ($1.28\times10^{1} \pm 1.67\times10^{0}$ pCi/g) at SMR. In intermediate depth soils, concentrations of ^{40}K varied from $2.32\times10^{-1} \pm 3.15\times10^{-2}$ Bq/g ($6.27\times10^{0} \pm 8.51\times10^{-1}$ pCi/g) at SEC to $5.11\times10^{-1} \pm 6.73\times10^{-2}$ Bq/g ($1.38\times10^{1} \pm 1.82\times10^{0}$ pCi/g) at SMR. Potassium-40 concentrations in deep soils were lowest at WFF ($2.09\times10^{-1} \pm 2.76\times10^{-2}$ Bq/g ($5.65\times10^{0} \pm 7.46\times10^{-1}$ pCi/g) and highest at SMR ($5.62\times10^{-1} \pm 7.29\times10^{-2}$ Bq/g ($1.52\times10^{1} \pm 1.97\times10^{0}$ pCi/g).

The concentration of ^{40}K was not significantly different between depths or between years. The range of concentrations observed is consistent with the average natural ^{40}K concentration in soils around the world (4.00×10^{-1} Bq/g [1.08×10^{1} pCi/g]; NCRP, 1994).

Cesium-137 was detected in 17 of the 18 soil samples (Table 4.13). In surface soils, concentrations ranged from $9.29\times10^{-4} \pm 5.14\times10^{-4}$ Bq/g ($2.51\times10^{-2} \pm 1.39\times10^{-2}$ pCi/g) at SMR to $8.88\times10^{-3} \pm 1.22\times10^{-3}$ Bq/g ($2.40\times10^{-1} \pm 3.30\times10^{-2}$ pCi/g) at MLR. The concentration in intermediate depth soils ranged from $1.16\times10^{-3} \pm 4.33\times10^{-4}$ Bq/g ($3.14\times10^{-2} \pm 1.17\times10^{-2}$ pCi/g) at SMR to $1.65\times10^{-2} \pm 2.16\times10^{-3}$ Bq/g ($4.46\times10^{-1} \pm 5.84\times10^{-2}$ pCi/g) at MLR. In deep soils, the lowest concentrations of ^{137}Cs were found at SMR ($7.55\times10^{-4} \pm 5.00\times10^{-4}$ Bq/g [$2.04\times10^{-2} \pm 1.35\times10^{-2}$ pCi/g]) and the highest concentrations were found at MLR ($1.48\times10^{-2} \pm 2.01\times10^{-3}$ Bq/g [$4.00\times10^{-1} \pm 5.43\times10^{-2}$ pCi/g]).

Table 4.13 - Selected Radionuclide Concentrations (Bq/g) in Soil Near the WIPP Site. See Appendix B for the sampling locations.

Location	Depth (cm)	[RN][a]	2 × TPU[b]	MDC[c]	[RN]	2 × TPU	MDC
		^{137}Cs			^{60}Co		
MLR	0-2	8.88×10^{-3}	1.22×10^{-3}	4.29×10^{-4}	2.97×10^{-4}	3.03×10^{-4}	4.81×10^{-4}
MLR	2-5	1.65×10^{-2}	2.16×10^{-3}	5.81×10^{-4}	-1.72×10^{-4}	4.88×10^{-4}	8.25×10^{-4}
MLR	5-10	1.48×10^{-2}	2.01×10^{-3}	8.07×10^{-4}	2.20×10^{-6}	4.33×10^{-4}	7.33×10^{-4}
SEC	0-2	2.82×10^{-3}	5.48×10^{-4}	5.14×10^{-4}	2.28×10^{-4}	2.34×10^{-4}	3.68×10^{-4}
SEC	2-5	2.15×10^{-3}	4.51×10^{-4}	4.51×10^{-4}	7.22×10^{-5}	2.48×10^{-4}	4.22×10^{-4}
SEC	5-10	9.44×10^{-4}	3.77×10^{-4}	5.29×10^{-4}	8.55×10^{-5}	2.80×10^{-4}	4.74×10^{-4}
SMR	0-2	9.29×10^{-4}	5.14×10^{-4}	7.81×10^{-4}	3.66×10^{-4}	4.29×10^{-4}	6.92×10^{-4}
SMR	2-5	1.16×10^{-3}	4.33×10^{-4}	6.03×10^{-4}	1.82×10^{-4}	3.20×10^{-4}	5.25×10^{-4}
SMR	5-10	7.55×10^{-4}	5.00×10^{-4}	7.73×10^{-4}	2.11×10^{-4}	4.63×10^{-4}	7.59×10^{-4}
WEE	0-2	2.21×10^{-3}	5.48×10^{-4}	6.55×10^{-4}	8.29×10^{-5}	2.48×10^{-4}	4.22×10^{-4}
WEE	2-5	3.13×10^{-3}	5.33×10^{-4}	5.62×10^{-4}	-3.74×10^{-4}	4.14×10^{-4}	7.10×10^{-4}
WEE	5-10	2.49×10^{-3}	6.22×10^{-4}	7.62×10^{-4}	-5.03×10^{-4}	4.63×10^{-4}	7.88×10^{-4}
WFF	0-2	3.57×10^{-3}	5.40×10^{-4}	3.59×10^{-4}	-6.99×10^{-5}	1.75×10^{-4}	3.40×10^{-4}
WFF	2-5	4.48×10^{-3}	6.22×10^{-4}	3.89×10^{-4}	-1.96×10^{-5}	2.76×10^{-4}	4.66×10^{-4}
WFF	5-10	3.30×10^{-3}	4.88×10^{-4}	2.63×10^{-4}	2.13×10^{-4}	1.61×10^{-4}	2.46×10^{-4}
WSS	0-2	1.95×10^{-3}	4.11×10^{-4}	3.96×10^{-4}	5.85×10^{-5}	2.42×10^{-4}	4.14×10^{-4}
WSS	2-5	1.78×10^{-3}	5.07×10^{-4}	6.51×10^{-4}	-3.08×10^{-4}	4.22×10^{-4}	7.18×10^{-4}
WSS	5-10	1.10×10^{-3}	3.29×10^{-4}	4.07×10^{-4}	2.24×10^{-4}	2.49×10^{-4}	3.96×10^{-4}
		^{90}Sr			^{40}K		
MLR	0-2	-2.81×10^{-3}	1.14×10^{-2}	1.89×10^{-2}	4.51×10^{-1}	5.96×10^{-2}	9.14×10^{-3}
MLR	2-5	9.62×10^{-3}	1.27×10^{-2}	2.00×10^{-2}	4.77×10^{-1}	6.25×10^{-2}	1.38×10^{-2}
MLR	5-10	-3.96×10^{-4}	1.04×10^{-2}	1.72×10^{-2}	4.29×10^{-1}	5.66×10^{-2}	1.37×10^{-2}
SEC	0-2	4.37×10^{-3}	1.21×10^{-2}	2.05×10^{-2}	2.24×10^{-1}	3.05×10^{-2}	5.62×10^{-3}
SEC	2-5	1.29×10^{-2}	1.21×10^{-2}	1.97×10^{-2}	2.32×10^{-1}	3.15×10^{-2}	5.85×10^{-3}
SEC	5-10	1.17×10^{-2}	1.33×10^{-2}	2.18×10^{-2}	2.51×10^{-1}	3.39×10^{-2}	5.48×10^{-3}
SMR	0-2	-1.34×10^{-3}	1.26×10^{-2}	2.07×10^{-2}	4.74×10^{-1}	6.18×10^{-2}	1.34×10^{-2}
SMR	2-5	-2.93×10^{-3}	1.17×10^{-2}	1.94×10^{-2}	5.11×10^{-1}	6.73×10^{-2}	9.47×10^{-3}
SMR	5-10	3.37×10^{-3}	1.25×10^{-2}	2.13×10^{-2}	5.62×10^{-1}	7.29×10^{-2}	1.37×10^{-2}
WEE	0-2	1.79×10^{-2}	9.55×10^{-3}	1.60×10^{-2}	2.25×10^{-1}	3.07×10^{-2}	7.36×10^{-3}
WEE	2-5	-8.70×10^{-3}	9.07×10^{-3}	1.60×10^{-2}	2.50×10^{-1}	3.41×10^{-2}	1.33×10^{-2}
WEE	5-10	-3.15×10^{-3}	9.47×10^{-3}	1.63×10^{-2}	2.62×10^{-1}	3.55×10^{-2}	1.32×10^{-2}
WFF	0-2	-3.40×10^{-3}	9.32×10^{-3}	1.61×10^{-2}	2.53×10^{-1}	3.31×10^{-2}	4.33×10^{-3}
WFF	2-5	-4.22×10^{-3}	9.14×10^{-3}	1.58×10^{-2}	2.58×10^{-1}	3.40×10^{-2}	1.06×10^{-2}
WFF	5-10	-4.22×10^{-3}	9.51×10^{-3}	1.65×10^{-2}	2.09×10^{-1}	2.76×10^{-2}	4.63×10^{-3}
WSS	0-2	9.62×10^{-3}	1.25×10^{-2}	2.07×10^{-2}	2.29×10^{-1}	3.12×10^{-2}	6.96×10^{-3}
WSS	2-5	7.92×10^{-3}	1.24×10^{-2}	2.06×10^{-2}	2.44×10^{-1}	3.34×10^{-2}	1.33×10^{-2}
WSS	5-10	4.07×10^{-3}	1.20×10^{-2}	2.03×10^{-2}	2.35×10^{-1}	3.20×10^{-2}	5.74×10^{-3}

[a] [RN] = Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Although ^{137}Cs is a fission product, it is ubiquitous in soils because of global fallout from atmospheric nuclear weapons testing. In 1998, prior to WIPP accepting any waste, the average concentration of ^{137}Cs in soils around WIPP was 4.3×10^{-3} Bq/g (1.16×10^{-1} pCi/g). There was no statistically significant difference between concentrations measured in 2000 and 2001 (ANOVA, $p = 0.519$).

Strontium-90 was only detected at WEE, depth 0-2cm, slightly above the MDC (Table 4.13). However, ^{60}Co was not detected in any of the soil samples. There was nonsignificant difference in ^{60}Co concentrations between years ($p = 0.421$).

Soil samples collected from one location (WEE) were divided into two parts and analyzed separately (Table 4.14). Uranium-234, ^{238}U, ^{40}K, and ^{137}Cs were compared between the duplicates. Other radionuclides of interest had insufficient detections to allow a reasonable comparison. The RER was greater than one for ^{234}U and ^{238}U in all samples. However, it was less than one in one for ^{40}K analyses and ^{137}Cs analyses. A paired t-test indicated no significant difference between ^{234}U duplicates ($p = 0.624$) and between ^{238}U duplicates ($p = 0.666$). This circumstance indicates a lack of precision in these analyses, primarily due to the non-homogeneous distribution of radionuclides in soils. Because of small-scale differences in topography, soil type and structure, soil moisture, and other microenvironmental conditions, radionuclides are rarely homogeneously distributed in soils, and good agreement between duplicate samples is difficult to achieve. However, all the measurements were low, within the range of natural concentrations, and did not differ in time or space in such a way as to suggest WIPP-related contamination of the environment.

Table 4.14 - Results of Duplicate Soil Sample Analysis. Units are Bq/g. See Appendix B for the sampling locations.

Location	Depth (cm)	[RN][a]	2×TPU[b]	MDC[c]	RER[d]	[RN]	2×TPU[a]	MDC[b]	RER[c]
		^{234}U				^{238}U			
WEE	0-2	5.66×10^{-3}	1.35×10^{-3}	1.02×10^{-4}	2.94	6.85×10^{-3}	1.57×10^{-3}	1.01×10^{-4}	2.26
WEE D[e]	0-2	1.50×10^{-2}	2.88×10^{-3}	8.92×10^{-4}		1.39×10^{-2}	2.70×10^{-3}	8.88×10^{-5}	
WEE	2-5	6.73×10^{-3}	1.38×10^{-3}	7.81×10^{-5}	2.63	7.33×10^{-3}	1.48×10^{-3}	7.77×10^{-5}	2.81
WEE D[e]	2-5	1.57×10^{-2}	3.12×10^{-3}	9.99×10^{-5}		1.81×10^{-2}	3.53×10^{-3}	9.92×10^{-5}	
WEE	5-10	1.84×10^{-2}	3.68×10^{-3}	2.83×10^{-4}	1.94	2.00×10^{-2}	3.96×10^{-3}	1.04×10^{-4}	1.90
WEE D[e]	5-10	1.01×10^{-2}	2.20×10^{-3}	3.00×10^{-4}		1.12×10^{-2}	2.39×10^{-3}	3.77×10^{-4}	
		^{40}K				^{137}Cs			
WEE	0-2	2.25×10^{-1}	3.07×10^{-2}	7.36×10^{-3}	0.40	2.21×10^{-3}	5.48×10^{-4}	6.55×10^{-4}	0.25
WEE D[e]	0-2	2.43×10^{-1}	3.30×10^{-2}	6.29×10^{-3}		2.40×10^{-3}	5.22×10^{-4}	5.55×10^{-4}	
WEE	2-5	2.62×10^{-1}	3.55×10^{-2}	1.32×10^{-2}	0.41	2.49×10^{-3}	6.22×10^{-4}	7.62×10^{-4}	0.18
WEE D[e]	2-5	2.42×10^{-1}	3.28×10^{-2}	6.36×10^{-3}		2.35×10^{-3}	4.74×10^{-4}	4.55×10^{-4}	
WEE	5-10	2.62×10^{-1}	3.55×10^{-2}	1.32×10^{-2}	0.22	2.49×10^{-3}	6.22×10^{-4}	7.62×10^{-4}	0.50
WEE D[e]	5-10	2.51×10^{-1}	3.42×10^{-2}	1.34×10^{-2}		2.12×10^{-3}	4.07×10^{-4}	5.14×10^{-4}	

[a] [RN] = Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative Error Ratio
[e] Duplicate

4.7 Sediments

4.7.1 Sample Collection

Sediment samples were collected from 12 locations around the WIPP site, mostly from the same water bodies from which the surface water samples were collected (Figure 4.7, see Appendix B for location codes). The samples were collected in 1 l